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## Comments:

1. Applicant has changed the title to be more descriptive of the invention. Further, applicant has amended claim 1 to particularly recite that the invention pertains to scatterometers which provide reflection coefficients as a function of wavelength and angle.

2. **The first rejection.** The Examiner has rejected claims 1-10, 19, 21-24 and 33 under 35 U.S.C. 103(a) as being unpatentable over Davidson et al (5,112,129) in view of See et al(applied Optics, 12/1996). The Examiner states that "It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the Davidson apparatus by imaging the back focal plane instead of the object plane because each point on the back focal plane corresponds to a plane-wave component incident at the object surface at a particular angle." (page 3 of the Office Action) Applicant respectfully traverses.

3. **Examiner's rejection is legally insufficient under 35 USC § 103.** *There is no suggestion in the art, or in See et al in particular, to image the back plane of an interference microscope having Koehler illumination.*

The Examiner states that the combination would be obvious "because each point on the back focal plane corresponds to a plane-wave component incident at the object surface at a particular angle." This language quoted by the Examiner comes from page 6664 of the See et al reference. However, this is not a suggestion to modify either the Davidson et al microscope or the See et al profiler. It is certainly not a suggestion to "image" the back focal plane of the Davidson et al (5,112,129) microscope. Rather, the quoted language is merely an explanation of the operation of the optical surface profiler described in See et al.

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Further, there is no suggestion in the prior art that such a combination would have a reasonable expectation of success. Indeed, the prior art does not suggest that such a combination would have any utility whatsover. The utility only becomes apparent with an understanding of the original theory and the novel processing advanced in the present application. Significantly, the See et al reference does not suggest the use of Koehler illumination and in fact teaches the use of highly coherent laser illumination instead. Further still, neither the processing taught in Davidson et al nor the processing taught in See et al would make the resulting configuration useful.

The law requires that there be a suggestion in the prior art that the components be combined and further requires that the prior art indicate that such a combination would have a reasonable expectation of success. These requirements are strongly adhered to in fields such as optical inspection which are highly studied and well published. Examiner has improperly applied hindsight and used the present invention as a blueprint to find the components of the present invention. The law requires more than merely finding the components of an invention in different applications. Accordingly, Applicant requests a withdrawal of this rejection.

**4. In support of this interpretation of the law Applicant offers the following quotes from the Federal Circuit:**

> "The fact that a prior art device could be modified so as to produce the claimed device is not a basis for an obviousness rejection unless the prior art suggested the desirability of such a modification." In re Gordon, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

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"Both the suggestion and the expectation of success must be founded in the prior art, not in the applicant's disclosure." In re Dow Chemical Co., 837 F.2d 469, 5 USPQ2d 1529 (Fed. Cir. 1988)

"Where claimed subject matter has been rejected as obvious in view of a combination of prior art references, a proper analysis under § 103 requires, inter alia, consideration of two factors: (1) whether the prior art would have suggested to those of ordinary skill in the art that they should make the claimed composition or device, or carry out the claimed process; and (2) whether the prior art would also have revealed that in so making or carrying out, those of ordinary skill would have a reasonable expectation of success." In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)

"[A}lthough much had been written on anodization, in this highly studied field no reference or combination of references showed or suggested [ the patented] process as a whole." Fromson v. Anitec Printing Plates, Inc., 132 F.3d 1437, 45 USPQ2d 1269 (Fed. Cir. 1997)

These requirements have been followed in Rockwell International Corp. v United States, 147 F.3d 1358, 47 USPQ2d 1027 (Fed Cir. 1998); Smiths Industries Medical Systems, Inc. v Vital Signs, Inc., 50 USPQ2d 1641, superseded on rehearing, 183 F.3d 1347, 51 USPQ2d 1415 (Fed. Cir. 1999); Winner International Royalty Corp. v Wang, 202 F.3d 1340, 53 USPQ2d 1580 (Fed. Cir. 2000)

The MPEP 706.02(j) is consistent with this interpretation.

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5. *There is no suggestion in the See et al reference to image the back focal plane of an object illuminated with Koehler illumination.* The Examiner's combination of the Davidson et al microscope and the See et al optical surface profiler is non-obvious because of the incompatibility of Koehler illumination with the See et al apparatus. The Carre algorithm used in the See et al reference assumes coherent illumination and there is no suggestion that the Carre algorithm is functional with Koehler (non-coherent) illumination.

In particular, the cited references use distinctly different types of light sources. The Davidson et al reference teaches the use of a Koehler (non-coherent) light source and the See et al reference uses a highly coherent laser diode. The combination proposed by the Examiner would modify the Davidson et al microscope, which uses Koehler illumination, to obtain an image at the back focal plane. However, neither the Davidson et al nor the See et al reference teaches that the resulting would have any utility, and neither the Davidson et al reference not the See et al reference teaches how such an image would be processed.

In particular, the See et al apparatus teaches the use of a highly coherent laser diode as a light source and the Carre algorithm taught by See et al assumes highly coherent illumination. Thus, the See et al reference teaches AWAY from Koehler illumination. Further, there is no suggestion that the Carre algorithm would be functional in such a system. The use of Koehler illumination is a requirement of all claims in the present application and provides a unique advantage in the present invention. Accordingly, Applicant respectfully requested the withdrawal of this rejection.

6. *A brief technical discussion of the light sources.* As described in the present application, Koehler illumination is characterized by a minimum of spatial coherence between any two points on back focal plane 50. That is, in Koehler illumination, the

mutual coherence function is nearly zero for any spaced-apart two points on back focal plane 50. In contrast, the See et al apparatus uses a laser diode (670-nm wavelength) as an illumination source. As is typical of most lasers, the spatial coherence from such a laser is very high. These two types of illumination are quite distinct. Further, the properties of resulting images and the processing required to extract useful data from images illuminated with different types of illumination are significantly different in devices such as those under discussion. Thus the illumination type is an integral design component of optical instruments such as spectrometers, ellipsometers and microscopes. They are not interchangeable in the claimed apparatus and methods.

*7. The language recited by the Examiner teaches away from the proposed combination.* The Examiner recites the language of See et al "That each point at the back focal plane corresponds to a plane-wave component incident at the object surface at a particular angle." This well known fact results from the fact that the image at the back focal plane corresponds to the *Fourier transform* of the object plane. However, for this very reason, the image of this Fourier transform is completely out-of-focus. (In a microscope, it is desirable that each point on the image correspond to only one point on the object.) Attempting to image the back focal plane in Davidson et al ('129) would render the Davidson et al ('129) microscope inoperable for its intended purpose, which is to make a magnified image of the object that "looks" like the object. In fact, the knowledge that each point on the back focal plane corresponds to plane-wave component incident at the object surface would lead a designer of a microscope avoid imaging the back focal plane, as his desire is to obtain a focused image of the object. Accordingly the language cited by the Examiner teaches away from modifying a microscope to image the back focal plane. This is further evidence that the combination is unobvious and that the rejection should be withdrawn.

**8. A brief technical discussion of the coherence probe microscope (Davidson '129) and discussion as to why one would not image the back focal plane of such a device.**

In particular, like the common optical microscope, a *coherence probe microscope* provides an *image* of a small object. More particularly, common optical instruments are impractical for precision surface images of integrated circuit surfaces because of the three-dimensional nature of such surfaces. Common optical microscopes can focus only one plane of the surface at a time, leaving the rest of the image out-of-focus. A coherence probe microscope combines images focused at varying elevations to provide an image that is entirely in-focus. The combined image, referred to as a "synthetic image" is produced by using an interference technique. More precisely, the mutual coherence function is calculated for each point on each image to determine which portions of the images are "in-focus." The in-focus portions of the images are then combined, resulting in a single in-focus "synthetic image." Significantly, the image produced is an improved *image* of the three-dimensional surface where all elevations are in-focus simultaneously.

As an example, a coherence probe image of a tiny house (taken from above) could be made by combining a number of images produced as the focus plane of the microscope is scanned through various elevations of the house. Each image would have one slice of the house in-focus, but the rest of the image would be out-of-focus. This is because microscopes at high magnifications cannot keep all elevations of a three-dimensional image in focus at the same time. The roof will be in focus in one image, the porch in another. Coherence probe microscopes overcome this problem by combining the in-focus portions of the various images. The roof is taken from the image wherein the roof is in-focus and the porch is taken from the image where it is in-focus. The combined ("synthetic") *image* is simply an in-focus top-down view of the tiny house. The advantage is that in the combined image, all elevations (the entire house) are in focus.

As described in detail above, the Davidson '129 reference describes an improved microscope that provides an improved image of small three-dimensional surfaces (such as the tiny house in the example). *However, "imaging the back focal plane" as suggested by the Examiner would not produce an image of the object.* This is because the back focal plane is "out-of-focus" from an imaging perspective. Since Davidson '129 teaches imaging, (i.e. an image of a tiny house looks like a magnified image of a tiny house). There would be no purpose to imaging the back focal plane. The resulting image would be completely out-of-focus.

9. *A surprising advantage results from the use of Koehler illumination in the present invention.* As described in the present application, current scatterometers are not capable of simultaneously measuring scattering data at multiple angles and wavelengths. It is desirable to illuminate the sample at multiple angles and wavelengths simultaneously in order to provide for a faster test. However, if the sample is illuminated at many angles at once, it is difficult to determine the intensity of the specular radiation measured by a detector. This is because light scatters in both specular and non-specular modes. That is, light incident from a given angle scatters in two modes. First, it scatters in a specular mode, where the angle of reflection equals the angle of incidence. Second, it scatters in a non-specular mode, where the angle of reflection is different from the angle of incidence. Thus, light received by a detector may include both light scattered in the specular mode from one incident angle and light scattered in a non-specular mode from a different incident angle. However, it is necessary to distinguish the specular terms from the non-specular terms in the data in order to develop accurate scattering data for the sample. Since it is difficult to distinguish light scattered in a specular mode from light scattered in a non-specular mode, scatterometers typically illuminate a sample at only one incident angle (or a narrow range of incident angles) at a time. If the detector is then positioned to receive only light reflected at this one angle, only light reflected in a specular mode is

detected. However, this adds time to the detection process and complexity to spectrographic instrument since it must include a mechanism for varying the angle of the illumination and/or detection if multiple angles are to be measured. The present configuration of imaging the back focal plane of an interference microscope illuminated with Koehler illumination allows the recovery of scattering data while the sample is simultaneously illuminated at different angles and wavelengths. On view of this surprising and advantageous result, the present invention is unobvious and Applicant requests the withdrawal of the rejection.

10. *Both references teach away from the suggested combination.* The See at all reference expressly teaches the use of a laser diode, which is a highly coherent source, and not a non-coherent Koehler source. This is a *teaching away* from the combination. Similarly, the Davidson et all ('129) reference expressly teaches the imaging of the image plane, not the back focal plane. This is a *teaching away* from combination. In fact, imaging the back focal plane in Davidson at al ('129) is the very opposite of imaging the object plane. (In the sense that the front plane provides the in-focus image of the object and the back focal plane provides a completely out-of-focus image that represents the Fourier transform of the object.) There is no suggestion in either reference of doing otherwise. This teaching away is evidence of the unobviousness of the present invention and further reason that the Examiner should withdraw his objection.

11. **The second rejection.** The Examiner has rejected claims 1-12, 19-26, 33 and 34 under 35 U.S.C. 103(a) as being unpatentable over deGroot(5,398,113) in view of See et al(applied Optics, 12/1996).

12. As noted by the Examiner, deGroot('113) teaches a coherence microscope. Like the Davidson at al discussed above, this microscope uses Koehler illumination and images the image plane, as is common in coherence microscopes. The Examiner states that "It

would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the deGroot apparatus by imaging the back focal plane instead of the object plane because each point on the back focal plane corresponds to a plane-wave component incident at the object surface at a particular angle." Applicant respectfully traverses for all of the same reasons provided above. Specifically, Applicant incorporates by reference paragraphs 3-10. The arguments are completely parallel, and all that needs to be done is to substitute "de Groot" for "Davidson et al.

13. The deGroot reference is similar to the Davidson et al reference in many aspects. One difference is that there is a form of Fourier analysis is deGroot. However this combination should be withdrawn for the same reasons as the first rejection. Further, the processing done by deGroot is distinguished from that claimed in the present invention.

In particular, the Examiner recites that deGroot applies "the principles of frequency-domain analysis to topography." However, topography is merely another word for mapping, or imaging. This is distinct from scatterometry, the subject of the present invention. In particular, neither de Groot or See et al teach performing Fourier transform analysis on multiple channels *to determine specular reflection coefficients* as particularly recited in claims 11,12, 25, and 26. Rather, de Groot appears to use a Fourier technique to determine an improved measurement of the height of an object, as is consistent with his goal of performing surface topography. There is no suggestion in either de Groot or in See et al that any form of Fourier analysis could determine specular reflection coefficients from an interference microscope illuminated with *Koehler illumination*. The use of Koehler illumination in a spectrometer, that is, a device that determines specular reflection coefficients, is not suggested by either reference.

14. **The third rejection.** The Examiner has rejected claims 12, 13, 20, 25-27 and 34 under 35 U.S.C. 103(a) as being unpatentable over Davidson et al (5,112,129) and See et

al(applied Optics, 12/1996) as applied to claims 1-10, 19, 21-24 and 33 above, and further in view of deGroot(5,398,113).

15. Examiner states in general terms that "It would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the Davidson apparatus to applying [sic] the principles of frequency-domain analysis to tomography to improve the tomographic measurements." Applicant respectfully traverses.

First of all, applicant wishes to clarify that "tomography" relates to imaging of planes. Many people are familiar with the medical use of CT scans, which provide images of planes in the body. Similarly, coherence microscopes provide scans of different elevations of microscopic objects. Coherence microscopes then use "coherence" to combine these scans to provide a single in-focus image of a 3-dimensional surface. As suggested above, de Groot uses a form of Fourier analysis to improve his images and to perform surface height calculations. However, none of the references teaches or suggests the use of Fourier analysis in a back-focal plane imaging system illuminated with a Koehler source to provide specular reflection coefficients as particularly recited in claims 12, 13, 25, or 26.

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16. Summary: The prior combination of microscopes (Davidson et al) and de Groot with a profiler/ellipsometer is not suggested anywhere in the art. Further, the utility of such a combination is nowhere suggested or explained in the prior art. Finally, the processing of such an image to provide specular reflection coefficients is not shown or suggested in the prior art. In particular, none suggests the surprising and advantageous result obtained by using Koehler illumination in a scatterometer which images the back-focal-plane of an interference microscope. That is, the ability to simultaneously illuminate an object at multiple angles and wavelengths and to then resolve the corresponding specular reflection coefficients. In view of these surprising and unexpected results the claims are unobvious and the rejections should be withdrawn and the claims as presently amended be allowed.

By: _Michael L Sherrard_ _July 21 2005_

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